Analysis for new Period 3 Events

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OUTLINE

ñ **New period 3 events**

- **ANN Selection**

- **Vertex predictions**

- **Results**

ñ **Conclusions**

ANN : Goal - Method

ñ **Goal :**

– Use **A**rtificial **N**eural **N**etworks to Select Neutrino Interactions that were missed from the initial scan.

ñ **Method :**

– Use the **existent ~ 900 neutrino interactions** as **"Signal"** and **equal number** of **background interactions** as **"Background"** to train the ANN that will perform the characterization.

ANN Input Variables

ñ **Scintillating Fiber System :**
- Total Number of SF hits (and Total number of "interaction" SF hits 500)
- Total Pulse height (and Total "interaction" Pulse Height, Pulse height cut @ 500)
- % of hits in Stations 1 2 3 4 & % of "Interaction hits "
- Number of SF lines (UZ,VZ)

ñ **Vector Drift Chambers:**
- Total Number of VDC hits

ñ **Drift Chambers:**
- Total number of DC hits
- Number of DC tracks

ñ **EMCAL :**
- Total Energy Deposition & Total Energy Deposition along $y = 0$ and $| x | > 100$ cm
- Number of clusters
- Average cluster energy
- Mean Cluster angle with respect to the z axis from the interaction point

ñ **Muon Identification System :**
- Total number of MID hits
- Total number of MID hits in the central tubes

ñ **Other Variables :**
- Number of 3D final Tracks & Number of 3D final tracks that have SF and DC hits.
- Trigger Timing Differences (T32,T21,T31)
- Reconstructed Vertex in the Emulsion Module
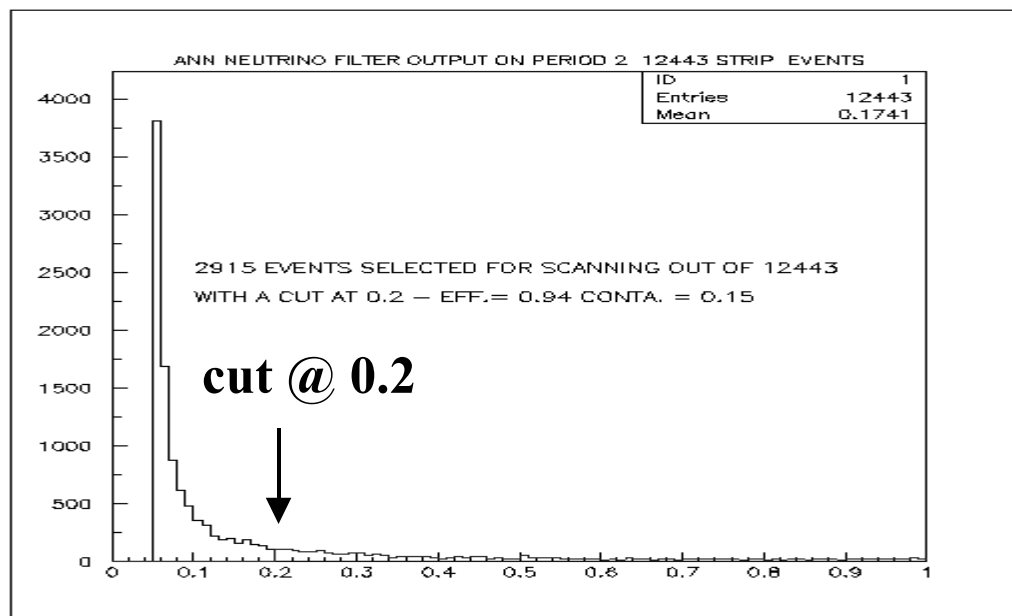
ANN Output Function
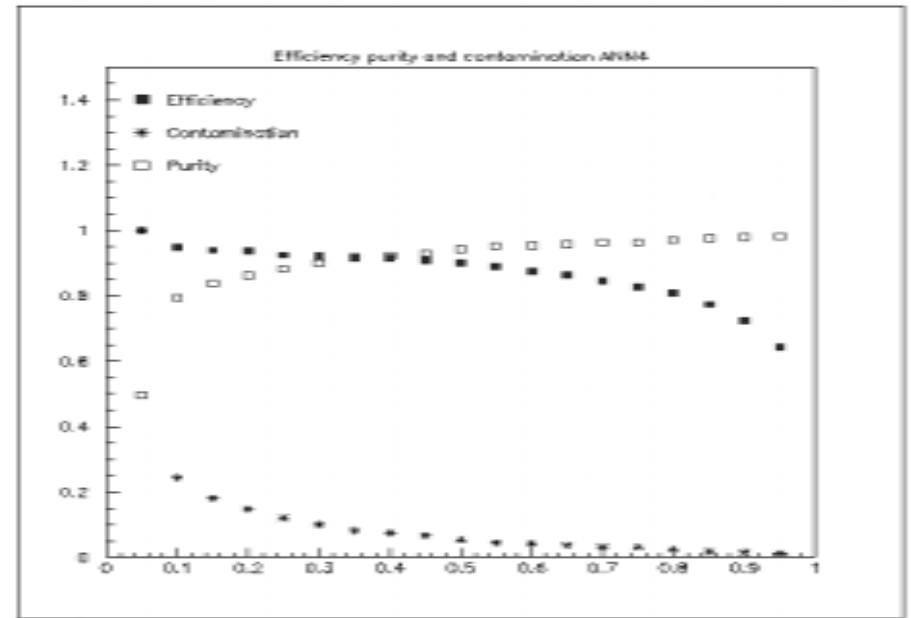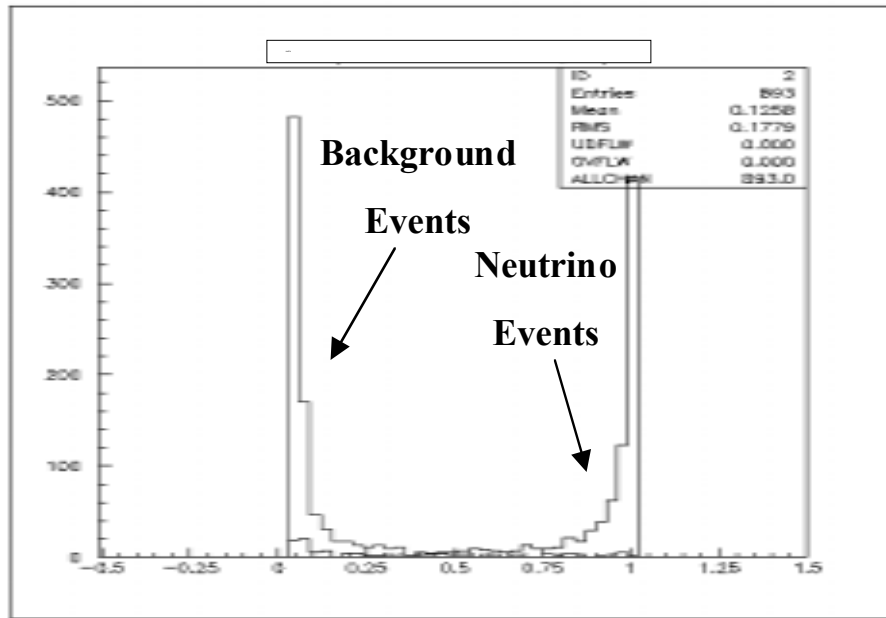
ñ The **performance** of the ANN is **good** and one can **select events** with **high efficiency** and **high purity** (**low contamination**).

ñ With a cut **@ 0.2** :

   efficiency 0.94 - purity 0.86 - contamination 0.15
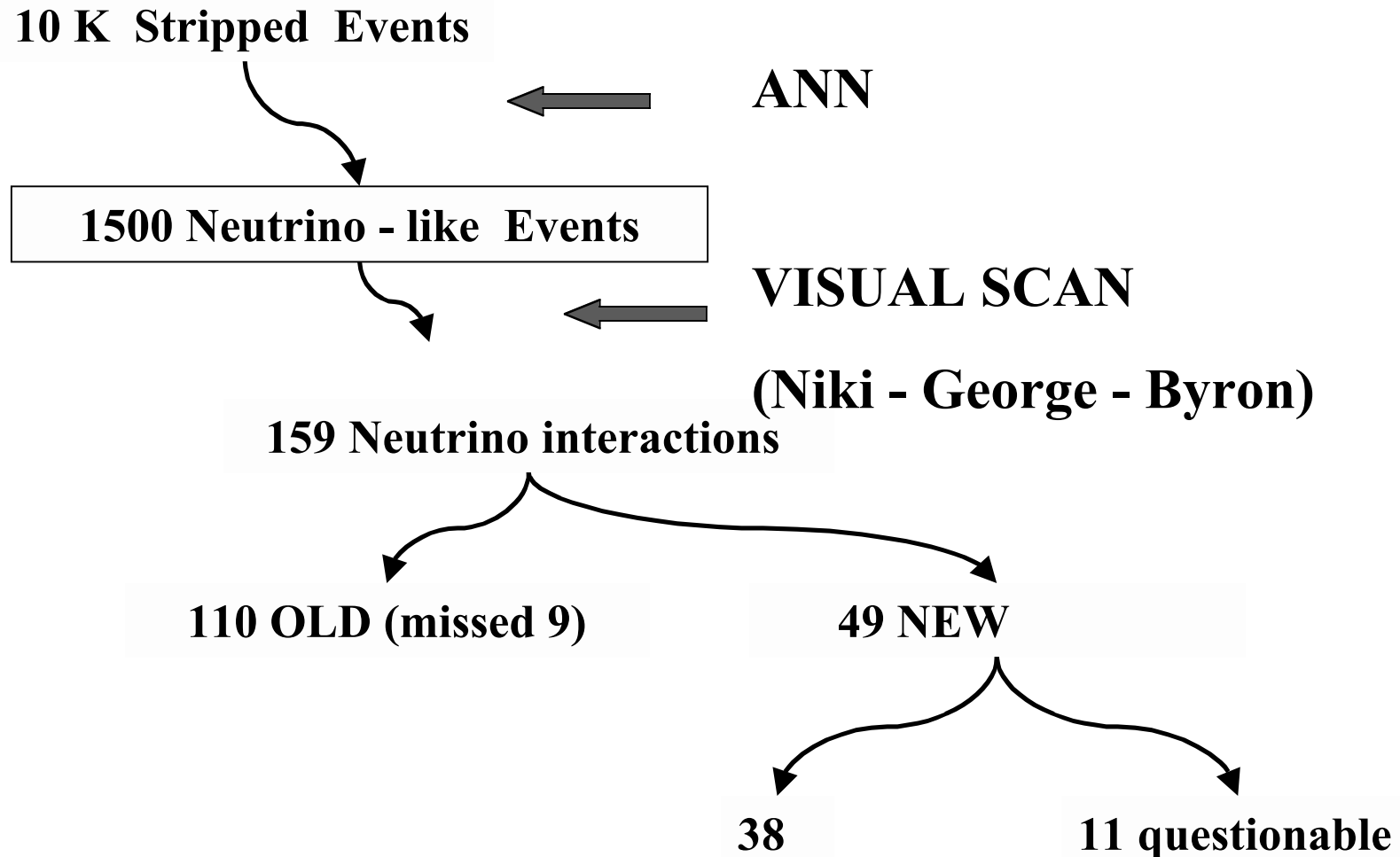
ANN Implementation &
Results on a "raw" Data Sample

ñ With a **cut @ 0.2   2915 out of 12443** are **selected** as "neutrino" interactions.

ñ **Initial   Signal/Background Ratio** ~ 100/12443 = **0.008**

ñ **Obtained Signal/Background Ratio** ~ 100/2915 = **0.034**

New period 3 neutrino interactions

10 K Stripped Events

ANN

1500 Neutrino - like Events

VISUAL SCAN

(Niki - George - Byron)

159 Neutrino interactions

110 OLD (missed 9)   49 NEW

38   11 questionable

Vertex Predictions :Goal - Main Idea

> **Goal** : To **predict** the vertex position with the desired accuracy (~ 2.5 mm in u & v and ~ 5 mm in z) with **minimal manual intervention**.

> **Main idea** : Use <u>confidently</u> reconstructed SF tracks and **minimize** the quantity :

$$\chi^2 = \frac{d^2_i}{\sigma^2_i}$$

where d_i = distance of SF track i from the vertex
$\hat{U}_i$ = error of d_i

Minuit for minimization

ñ The **initial minimization** code has been written **from scratch** using **MC** minimum **search** methods.

ñ As a way to **test** our **results** and obtain even better we have built up the whole **minimization procedure** using **minuit** routines :

- – *SEEK* for initial MC search of minimum
- – *MIGRAD* for derivatives search of minimum
- – *MINOS* for obtaining the error matrix

ñ Our **results** & **minuit results** are **very similar** but decided to use **MINUIT** since it is more **reliable** and **efficient** on obtaining **errors.**

^{2} **Minimization (MC Events)**
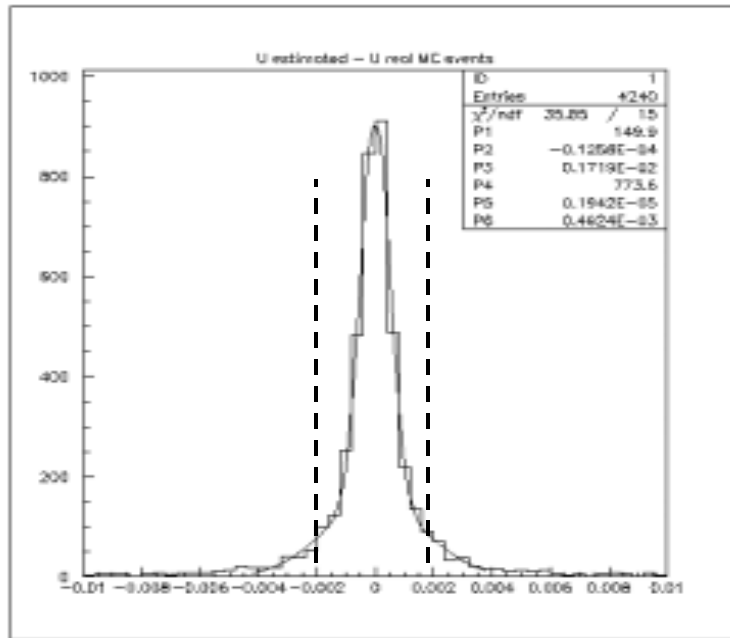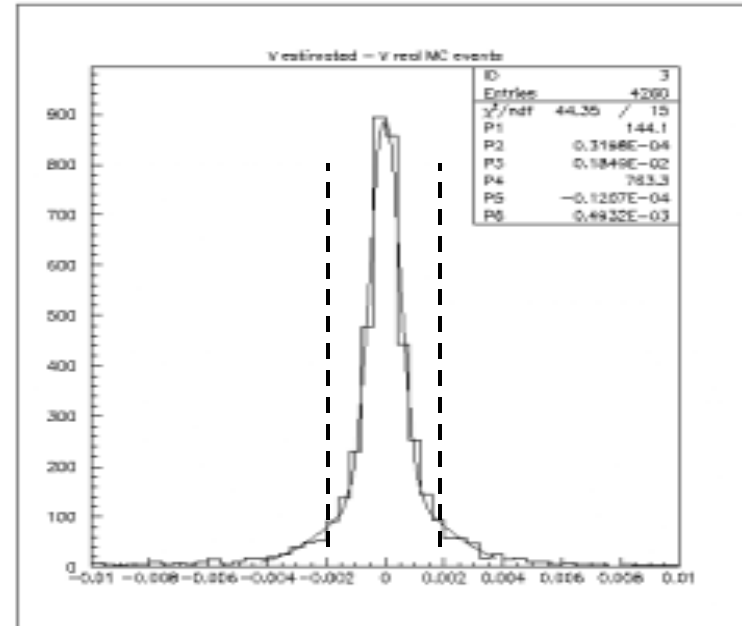
U$_{est}$ - U$_{real}$ 2 gaussian fit   V$_{est}$ - V$_{real}$
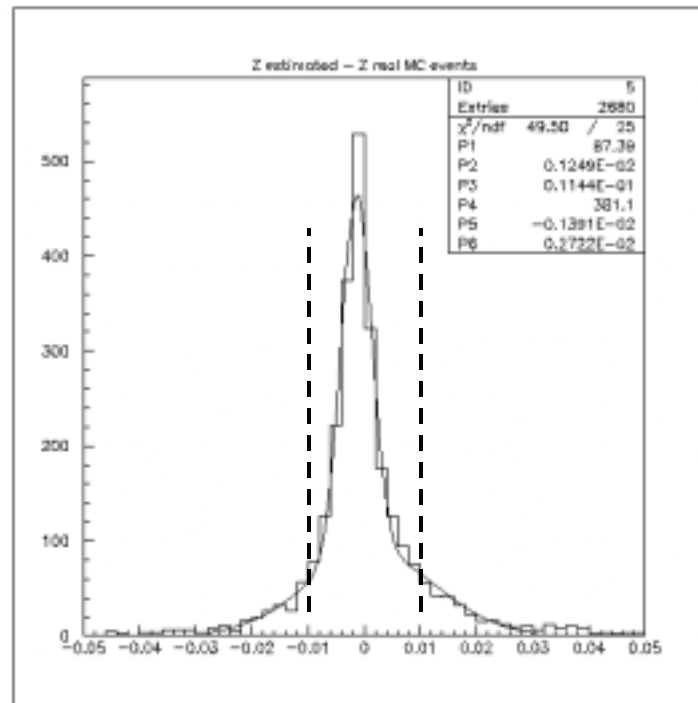

ñ In 16 % of events u,v-vertex is estimated with 1.72 mm sigma

ñ In 84 % of Events u,v-vertex is estimated with 0.49 mm sigma

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^{2} Minimization (MC Events)

2 gaussian fit

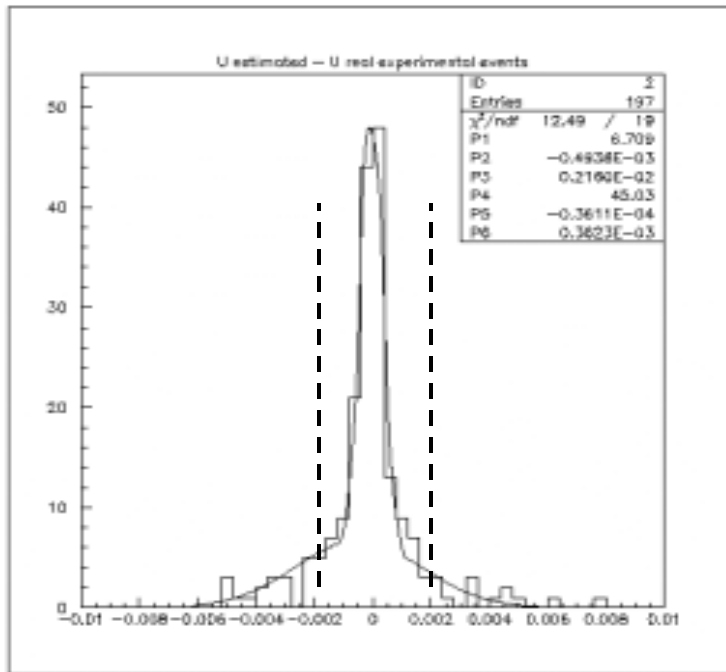$$Z_{est} - Z_{real}$$

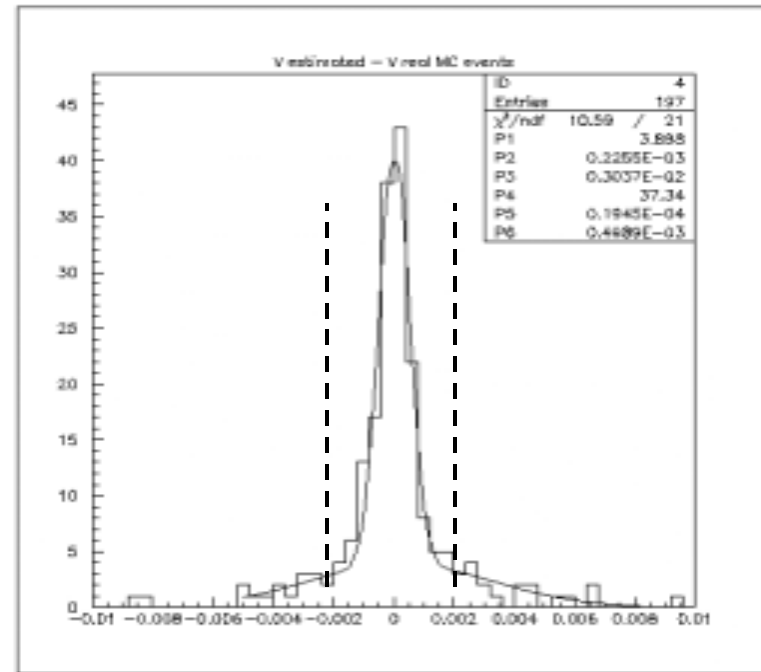ñ In 18 % of Events z-vertex is estimated with 11 mm sigma

ñ In 82 % of Events z-vertex is estimated with 2.7 mm sigma

^{2} **Minimization (203 Events)**
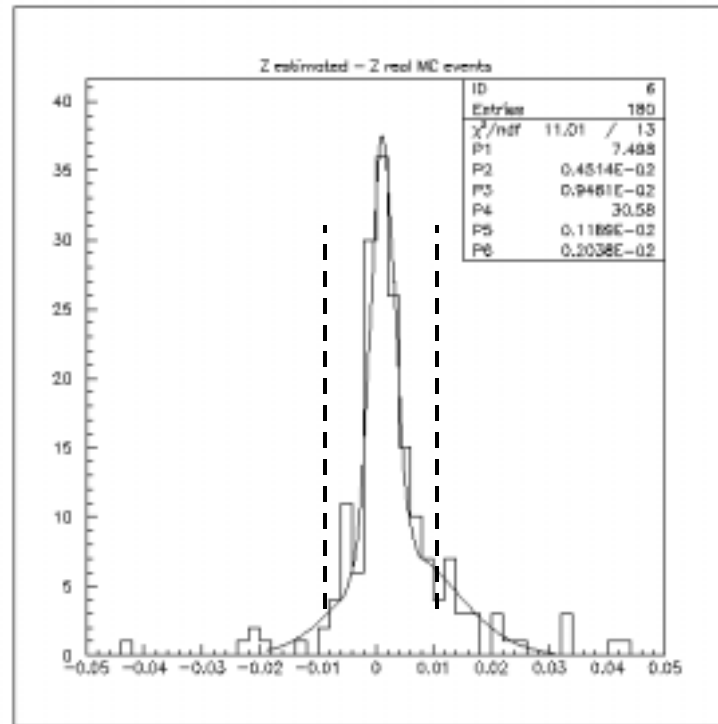

U_{est} - U_{real} 2 gaussian fit V_{est} - V_{real}

ñ In 13 % of events u,v-vertex is estimated with 2.50 mm sigma

ñ In 87 % of Events u,v-vertex is estimated with 0.49 mm sigma

^{2} **Minimization (203 Events)**

2 gaussian fit
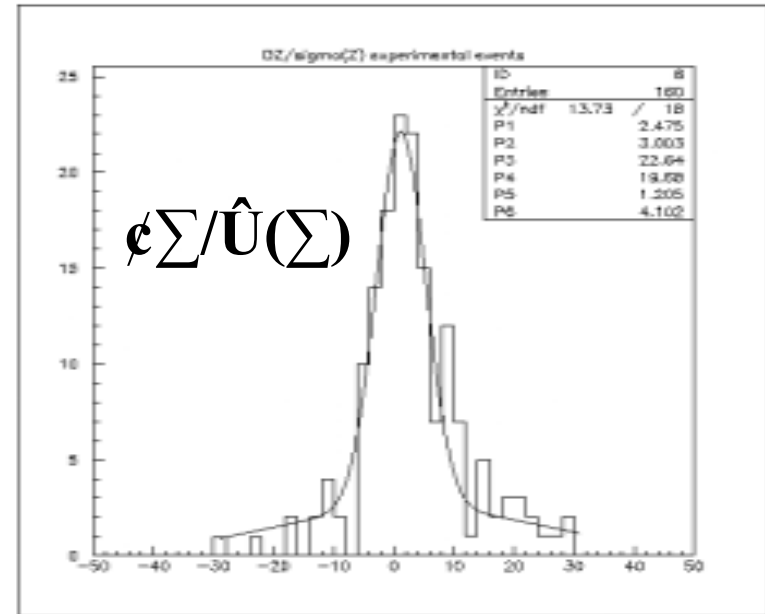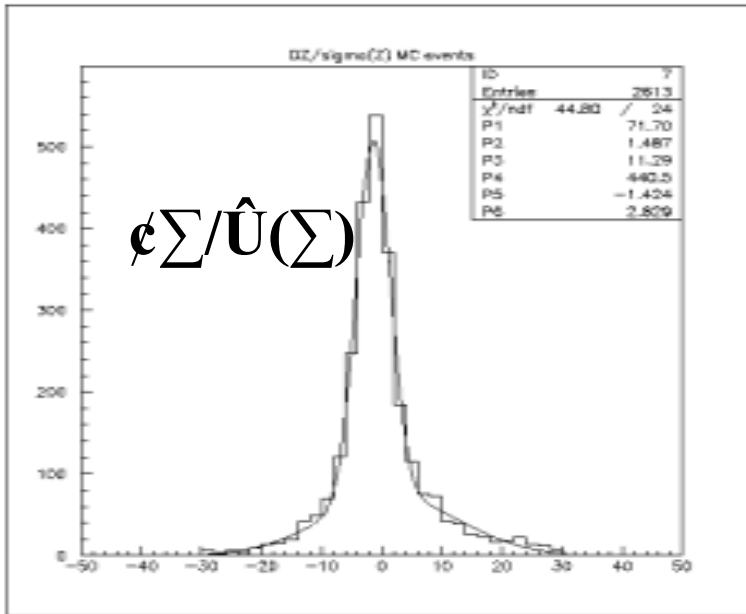

$Z_{est} - Z_{real}$

ñ In 20 % of Events z-vertex is estimated with 9.4 mm sigma

ñ In 80 % of Events z-vertex is estimated with 2.1 mm sigma
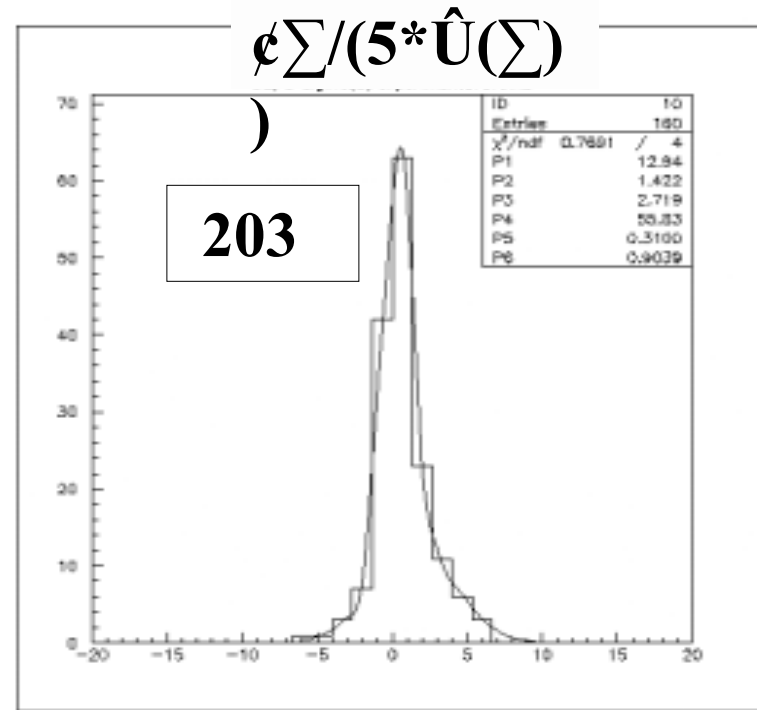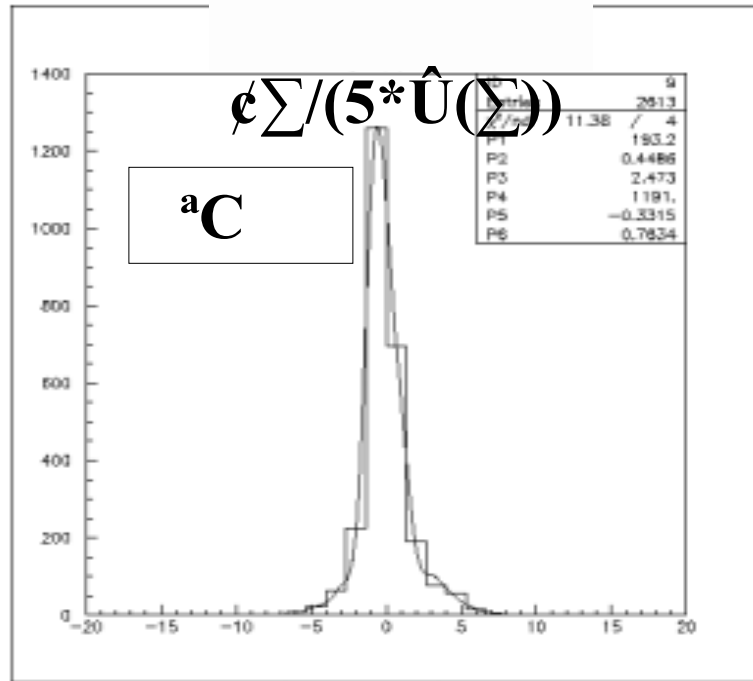
Minuit Z errors (MC &203 Events)

<div style="border:1px solid">**ªC**</div>   <div style="border:1px solid">**203**</div>
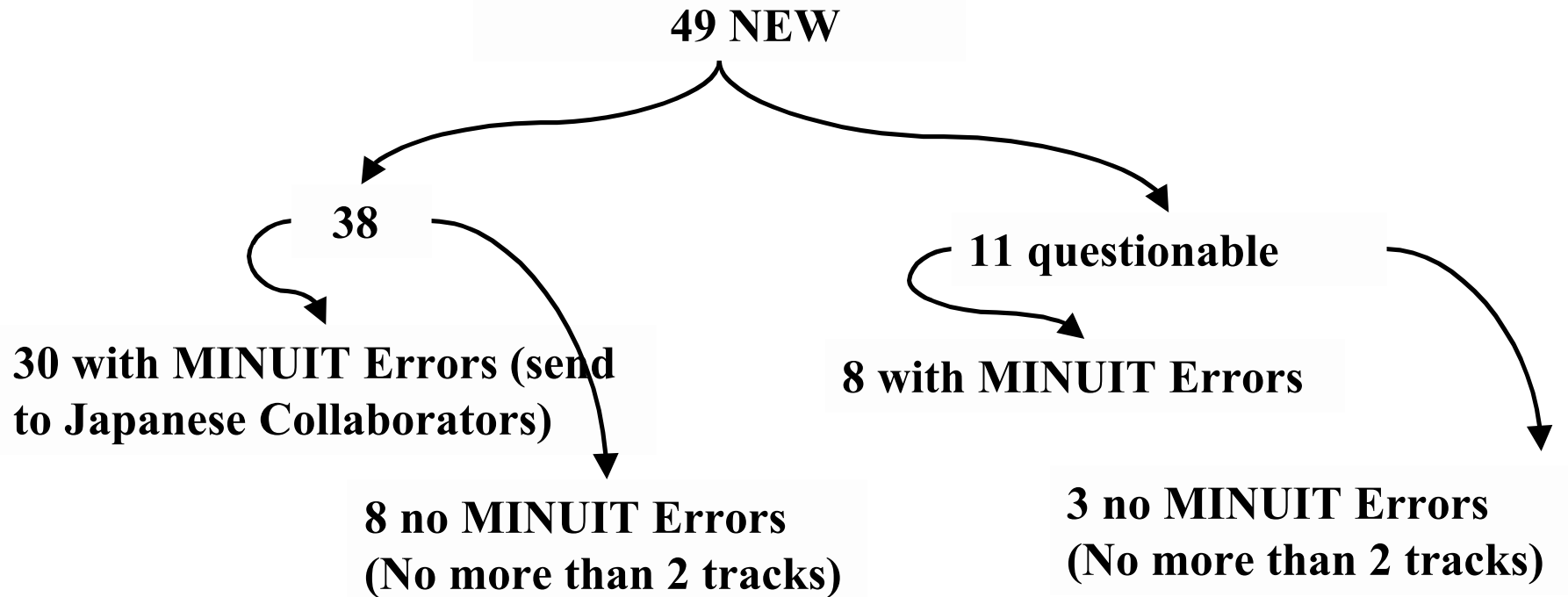

ñ Sigma of $\not c\sum/\hat{U}(\sum)$ distrubution apparently too large $<\,=\,>$
Too small errors.

ñ Thus introduce arbitrary multiplication factor on MINUIT
errors in order to achieve sigma of $\not c\sum/\hat{U}(\sum)$ distribution $\sim$ **1**

Minuit Z errors (MC &203 Events)

ñ   Introducing a multiplication **factor = 5** on MINUIT errors the $\not{c}\sum/(5*\hat{U}(\sum))$ distribution now becomes nearly **gaussian** with a **sigma of ~ 1.**

Vertex Predictions :New period 3 events

49 NEW

38

11 questionable

**30 with MINUIT Errors (send
to Japanese Collaborators)**

8 with MINUIT Errors

**8 no MINUIT Errors
(No more than 2 tracks)**

**3 no MINUIT Errors
(No more than 2 tracks)**

ñ Using the previously described procedure we obtained vertex predictions for the **new period 3 events** and **30** have already been **send** to our **Japanese Collaborators**

Conclusions - On going work

ñ Using **Neural Network Techniques** we have selected **new period 3 neutrino interactions** in a **satisfactory** way as far as **efficiency** and **timing** is concerned.

ñ Using **minimization techniques** we have obtained **quite accurate vertex predictions** for new period 3 events with **minimal manual intervention**.